

WDFW's Puget Sound steelhead monitoring program



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What makes a good monitoring program?

1. Sustainable in the long term

Detect signal amid noisy natural variation

2. Measures important biological parameters

Abundance, Productivity, Spatial Structure, Diversity

3. Identify sources of uncertainty and estimate precision

Evaluate confidence in making recovery decisions

Fish In, Fish Out

Marine processes:

- marine survival
- smolt-to-adult returns (SAR)

Adults



Freshwater processes:

- productivity
- capacity
- smolts per spawner

To assess productivity:

- abundance at each life stage
- age structure at each life stage

Smolts



Adult methods



Photo:
Larry Phillips

Challenge

Consequence

Protracted spawning

No or few observations in tails of spawning distribution

Vast spatial extent of spawning

Use index reaches to extrapolate to entire basin or population

River conditions: high flows and turbidity

Variable observation probability

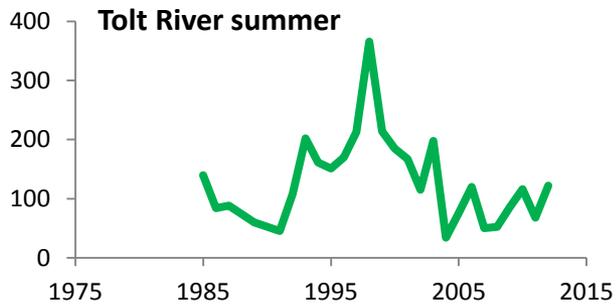
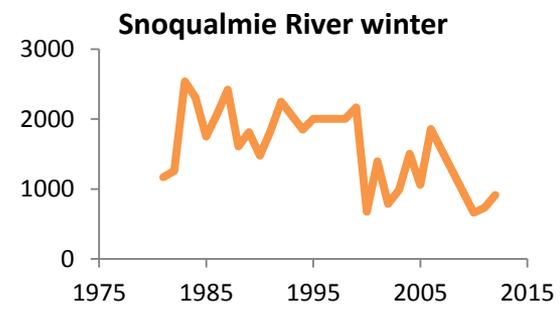
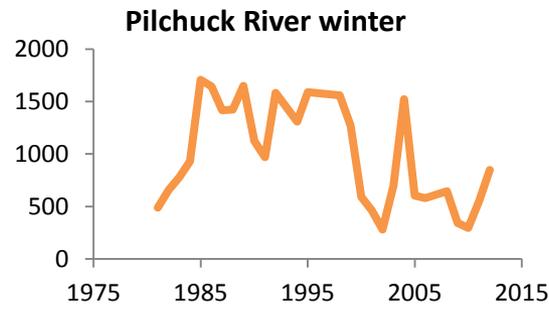
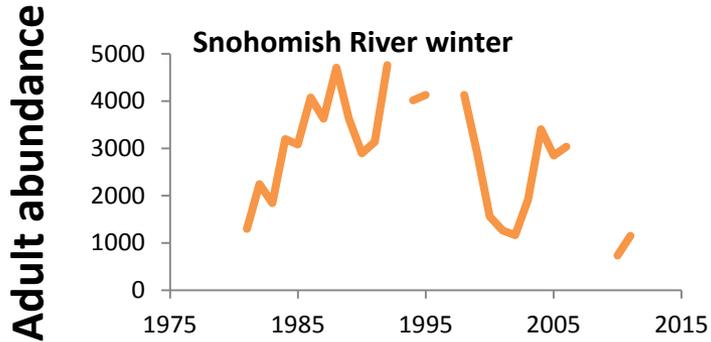
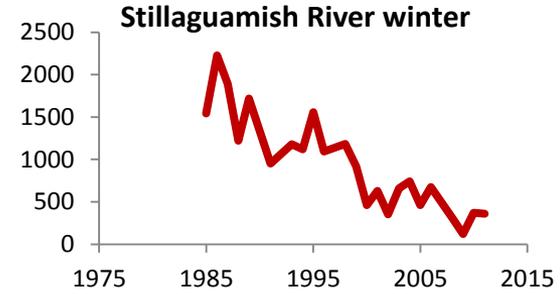
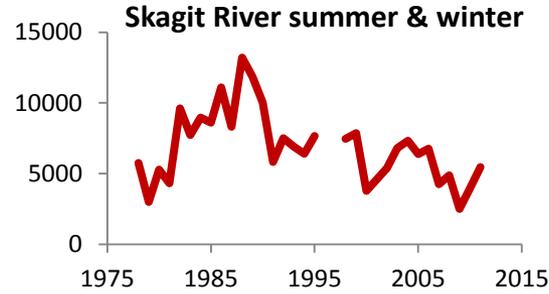
Fish rarely observed

Assumptions regarding sex ratio and redds per female

Fish not handled

No biological samples for age structure or hatchery fraction

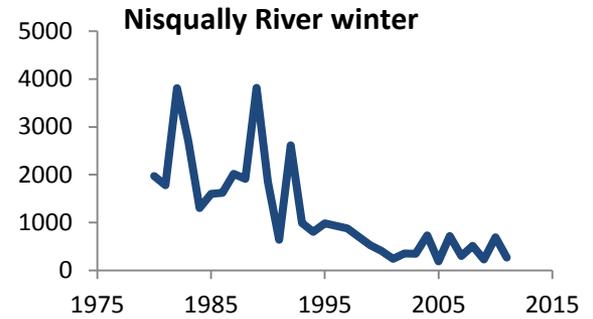
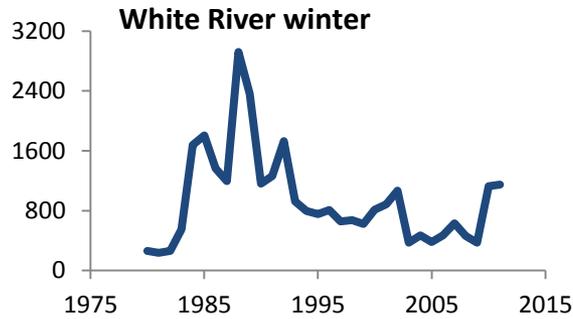
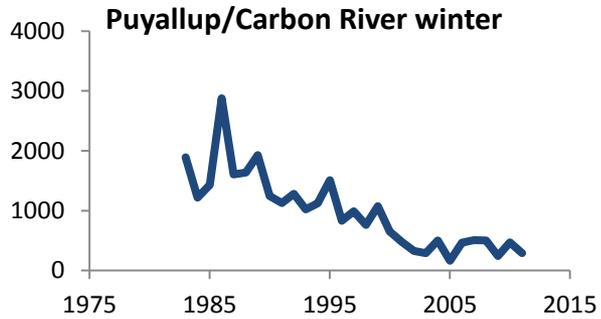
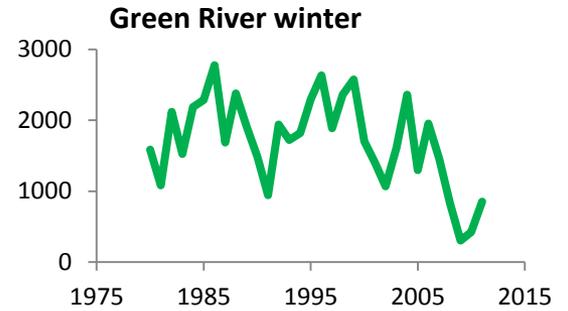
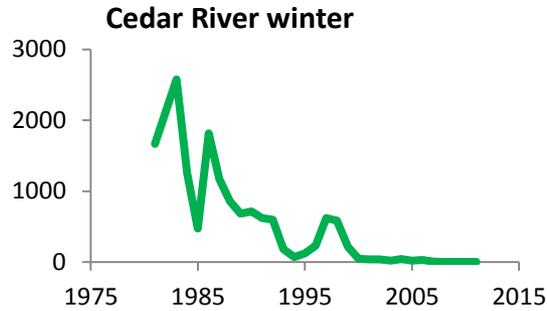
North Cascades MPG



Time series for 8 of 16 populations

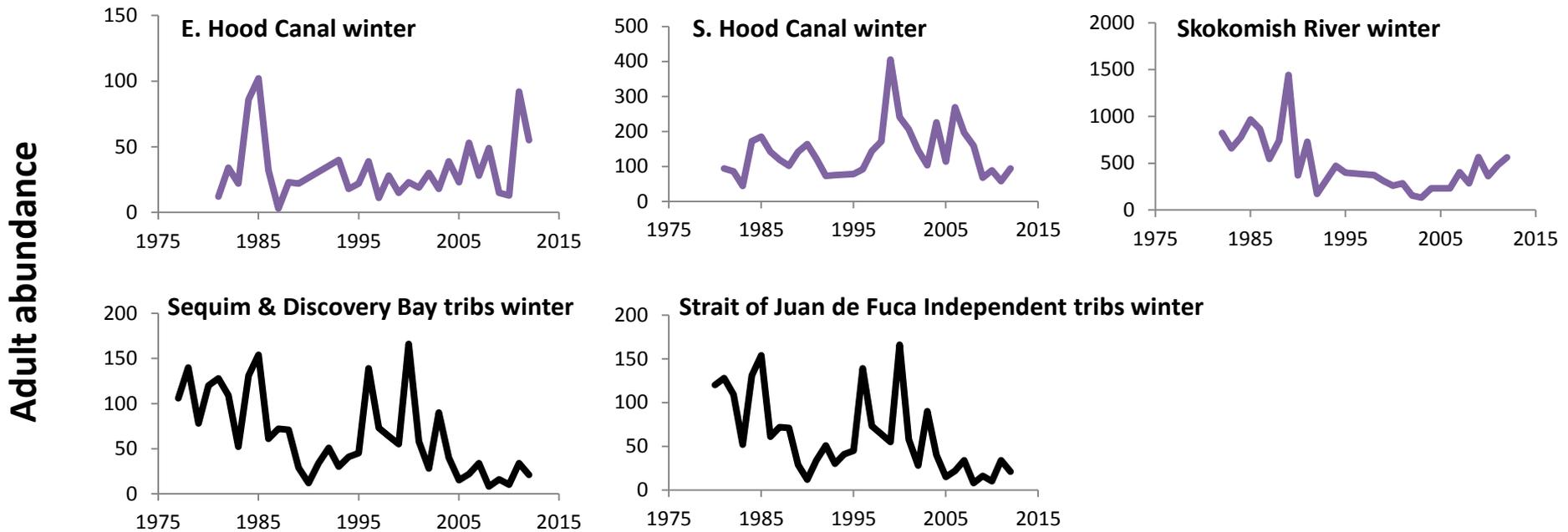
Central and South Sound MPG

Adult abundance



Time series for 5 of 8 populations

Hood Canal & Strait of Juan de Fuca MPG



Time series for 5 of 8 populations

Smolt methods – weir



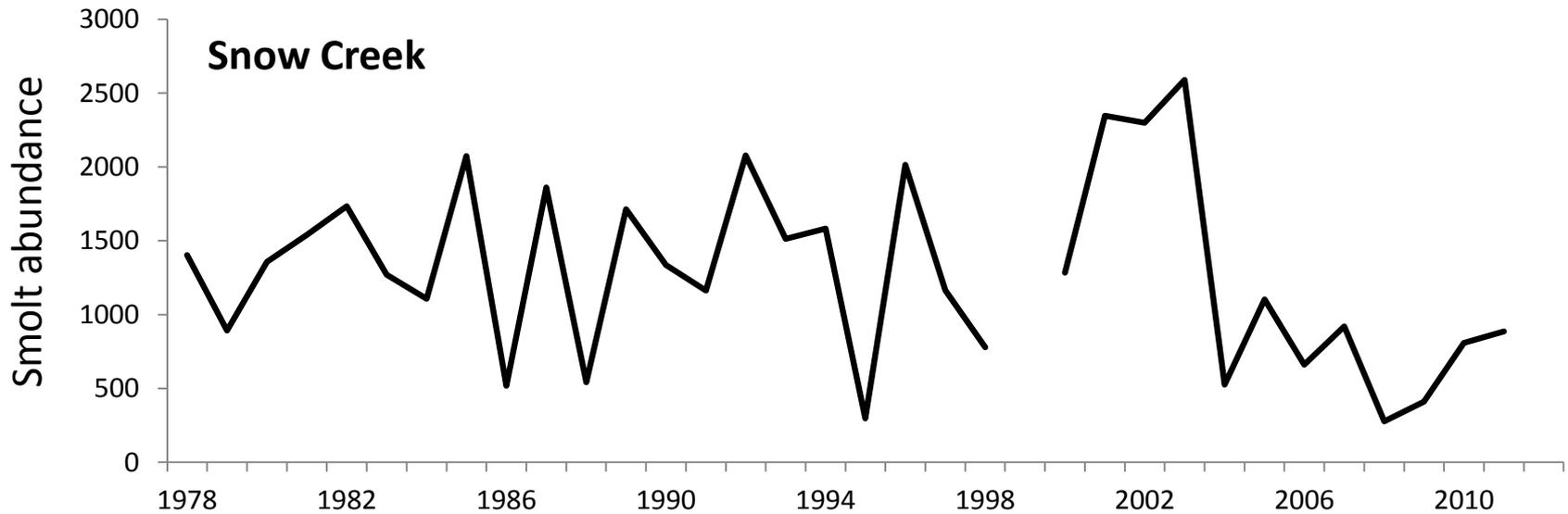
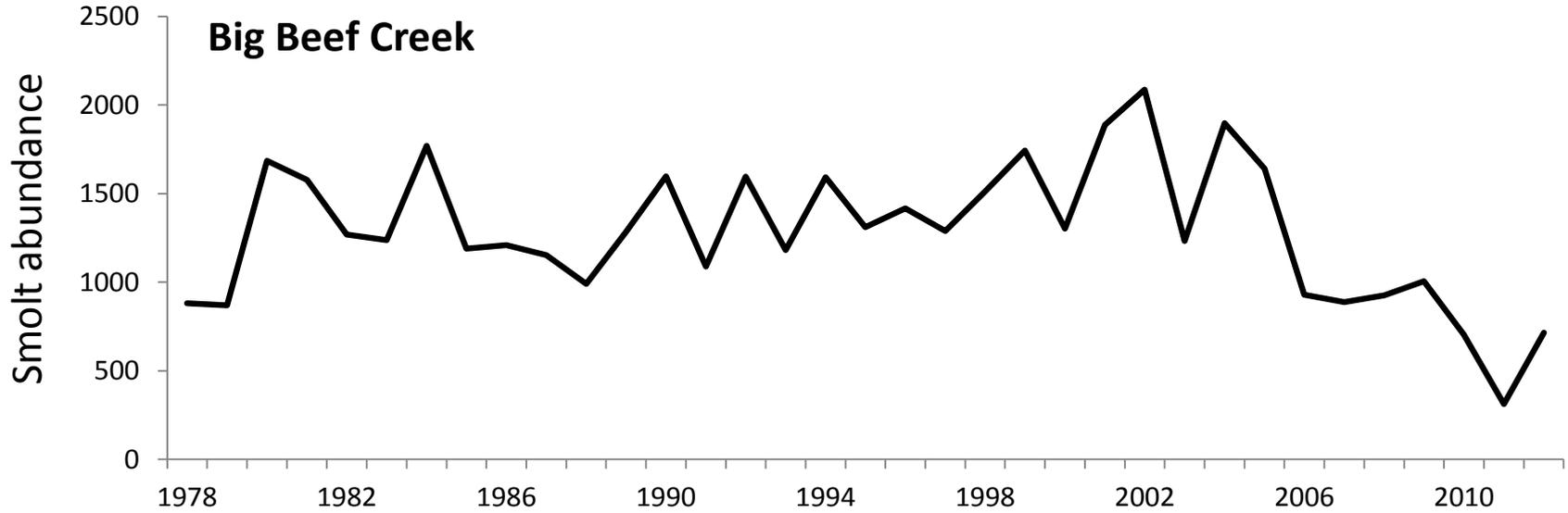
Challenge

Only feasible in small systems

Consequence

Difficult to extrapolate to large scale recovery actions in big rivers

Smolt abundance from weirs



Smolt methods – trap



Challenge

Consequence

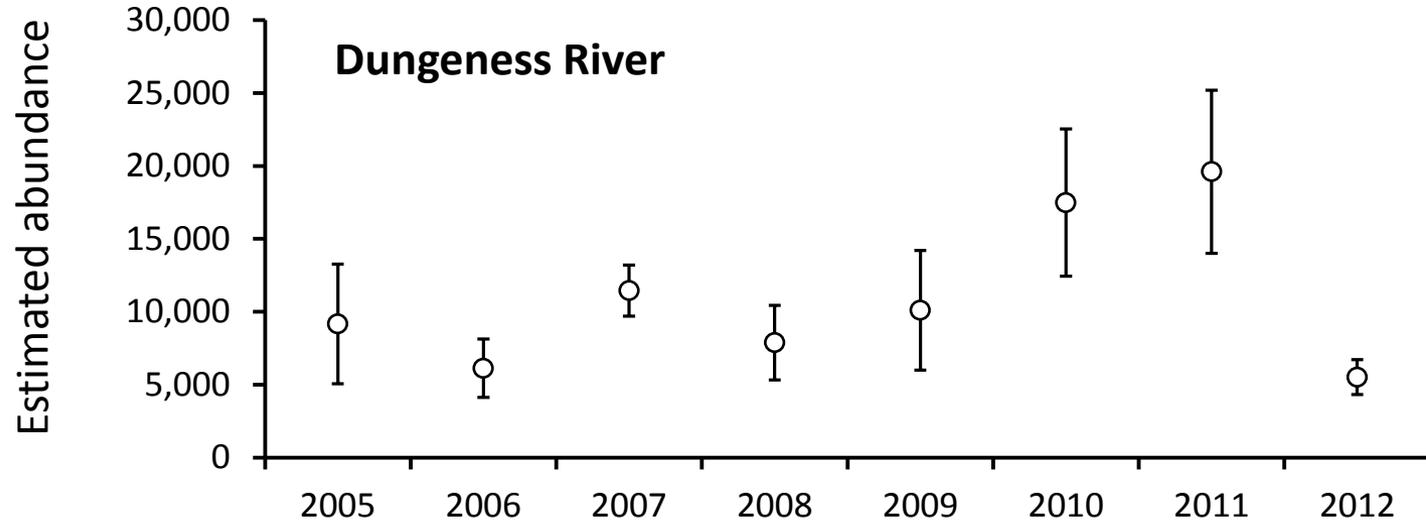
Small sample fraction

Robust abundance estimates require mark-recapture approaches

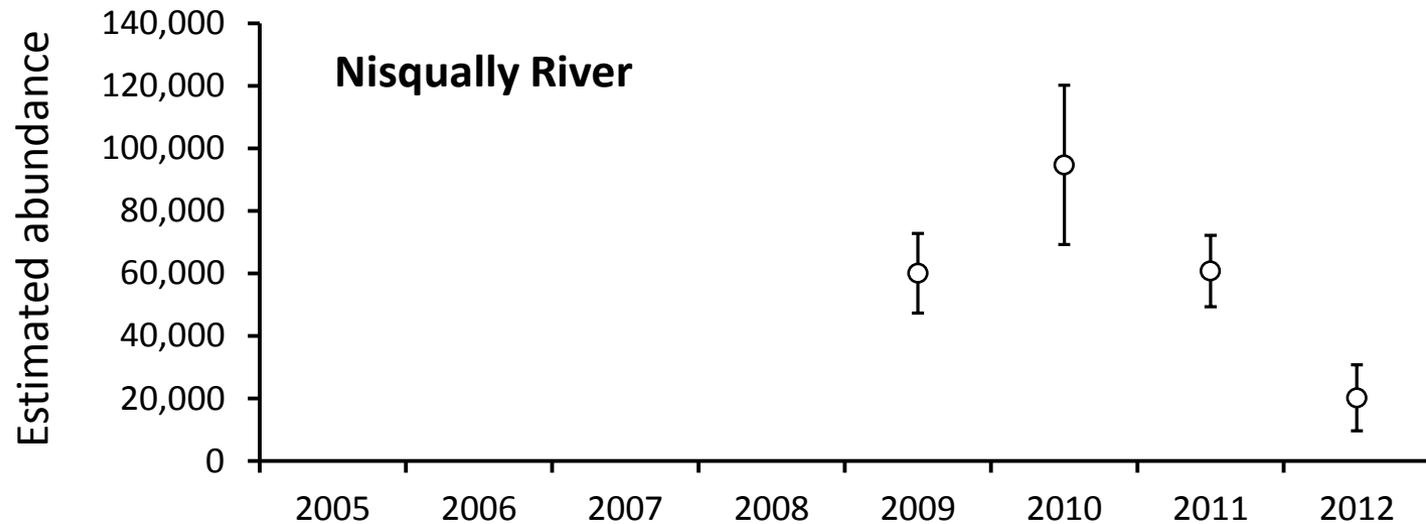
Trap sites chosen for salmon

Currently, few traps catch sufficient steelhead for mark-recapture

Smolt abundance estimates from traps

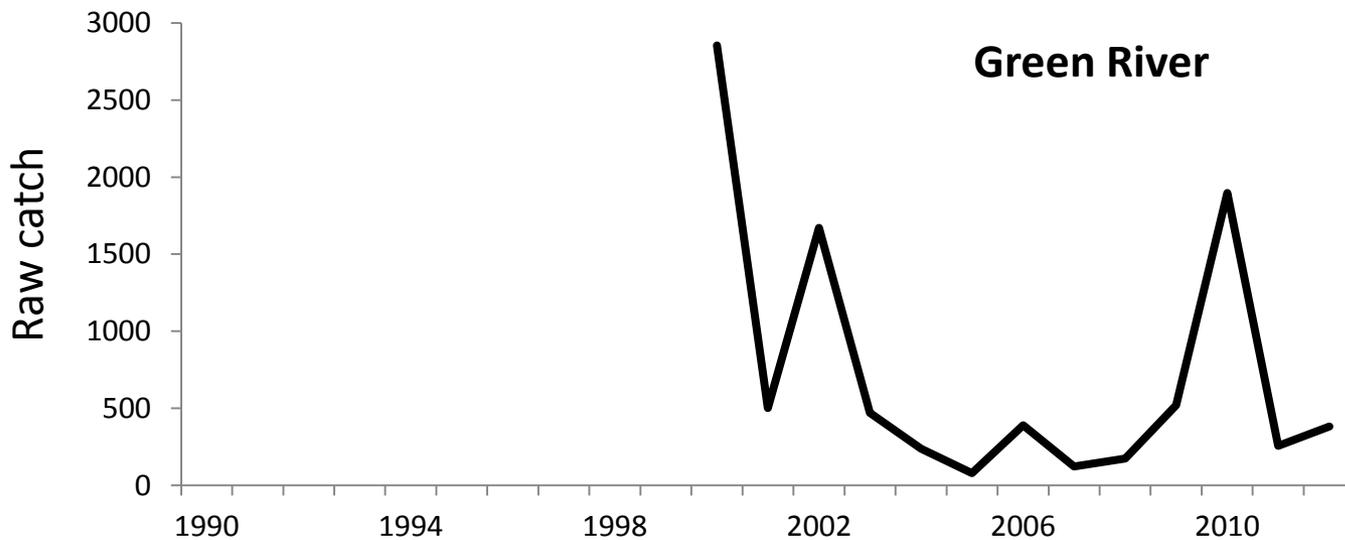
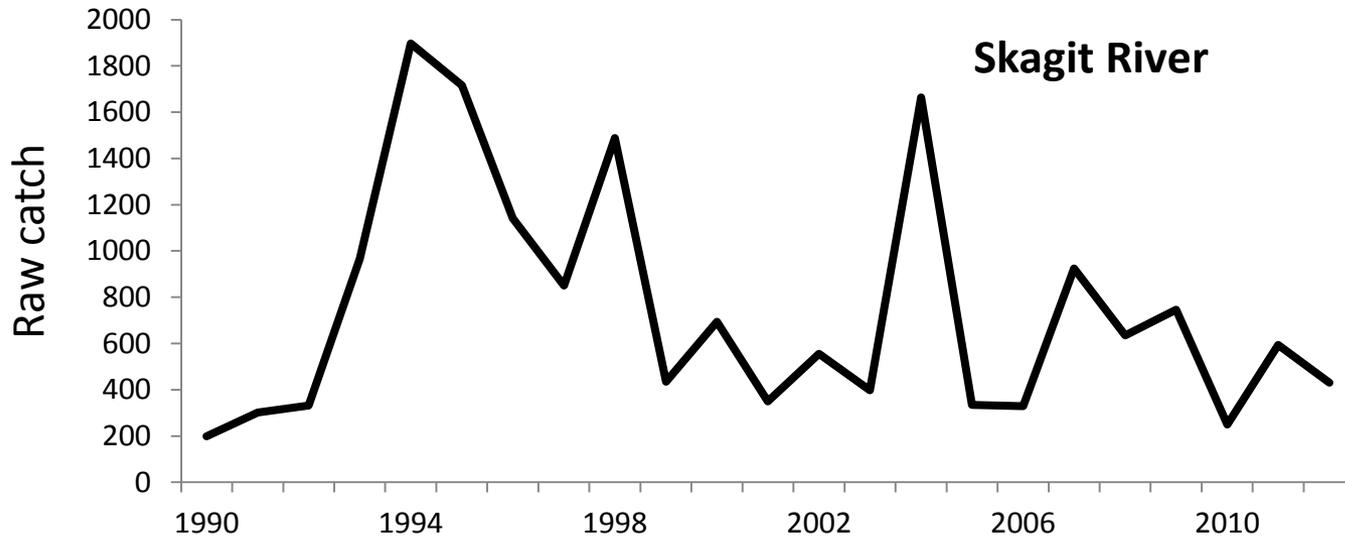


Two trap design



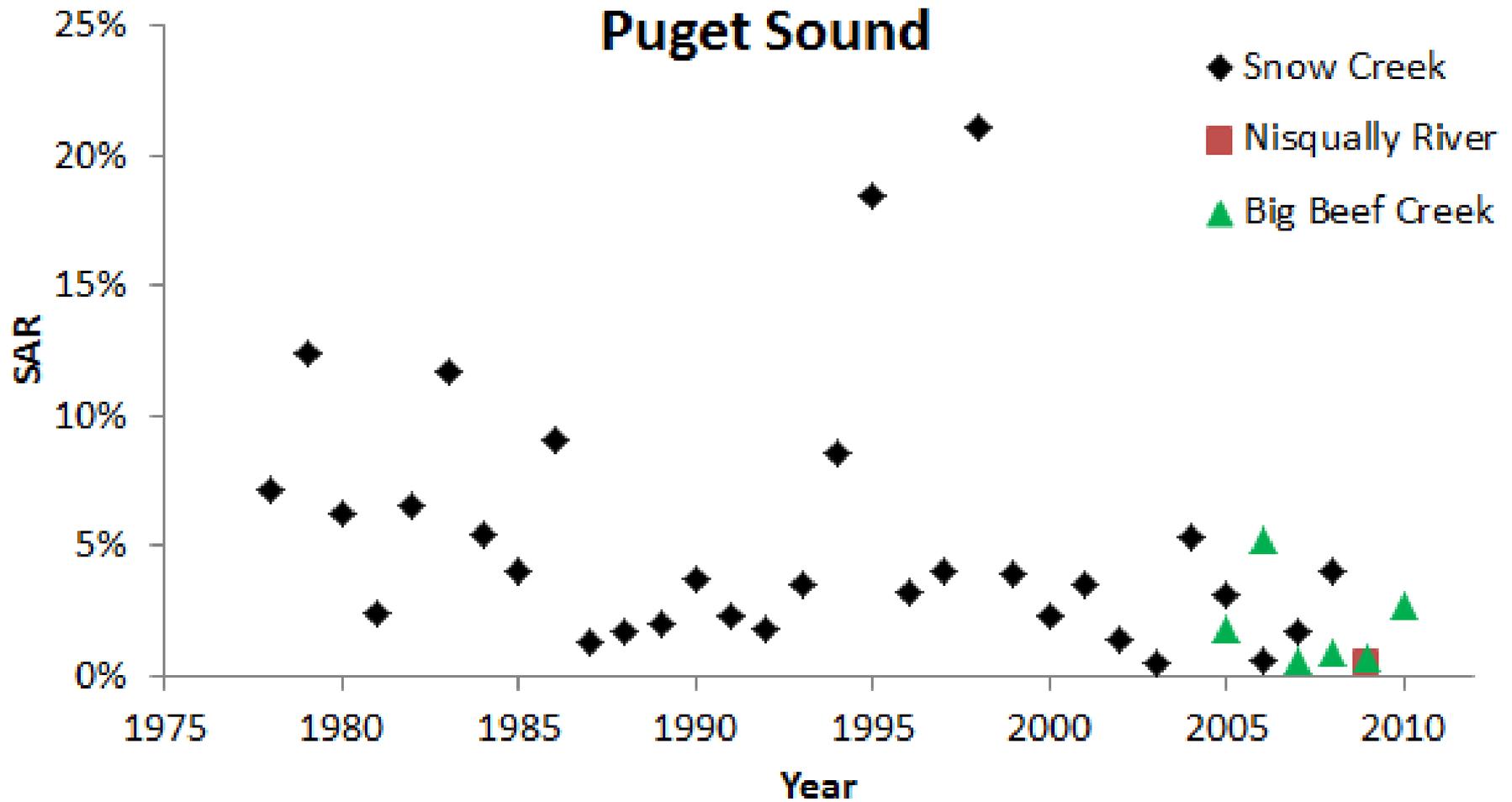
One trap design

Raw smolt catch



Year	Estimate \pm 95% CI
2009	26,174 \pm 16,024
2010	71,170 \pm 22,393

Wild marine survival



Diversity



Photo: Thomas Buehrens

Skagit tributaries



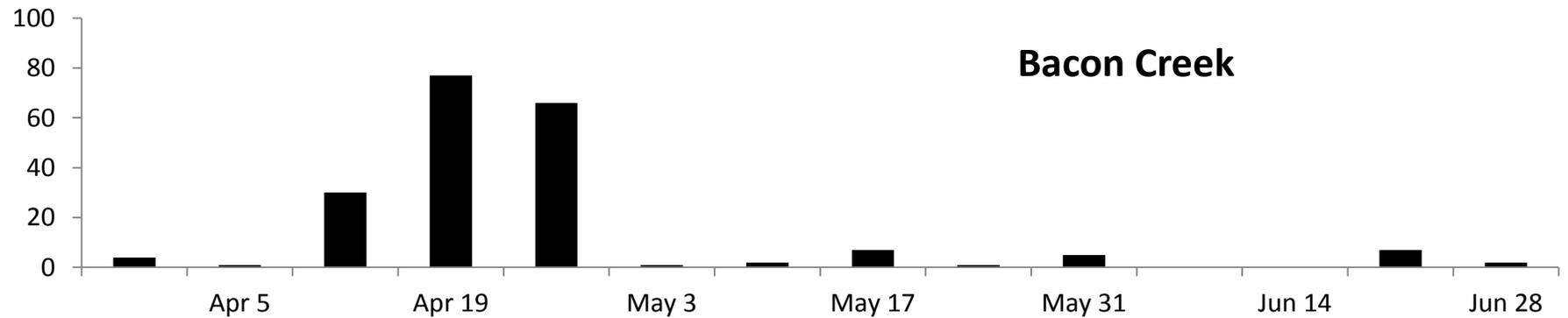
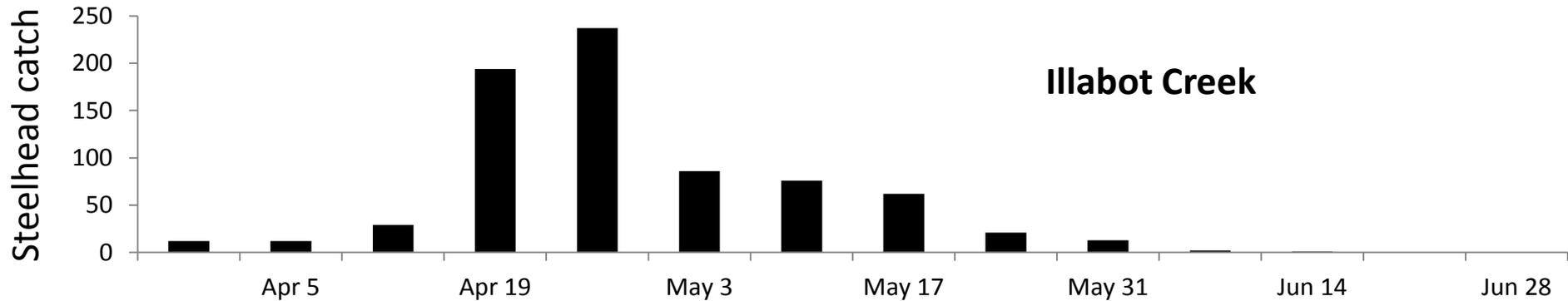
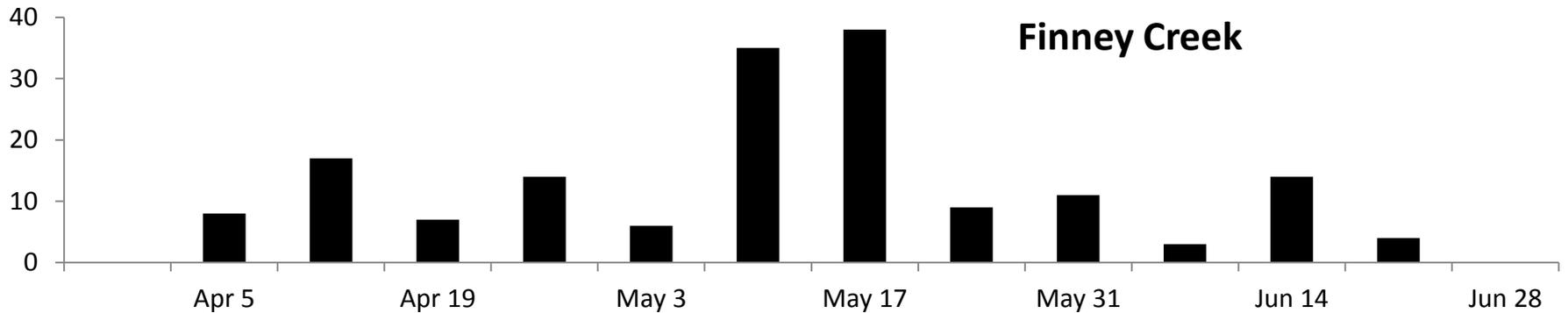
Finney Creek

Illabot Creek

Bacon Creek

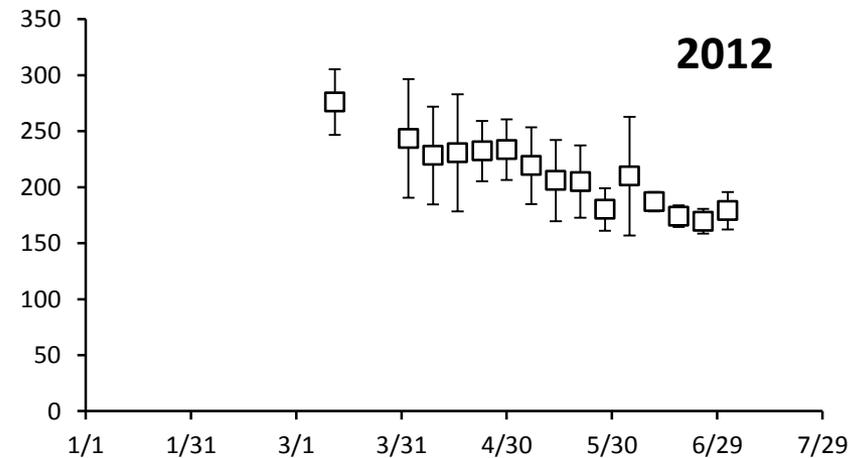
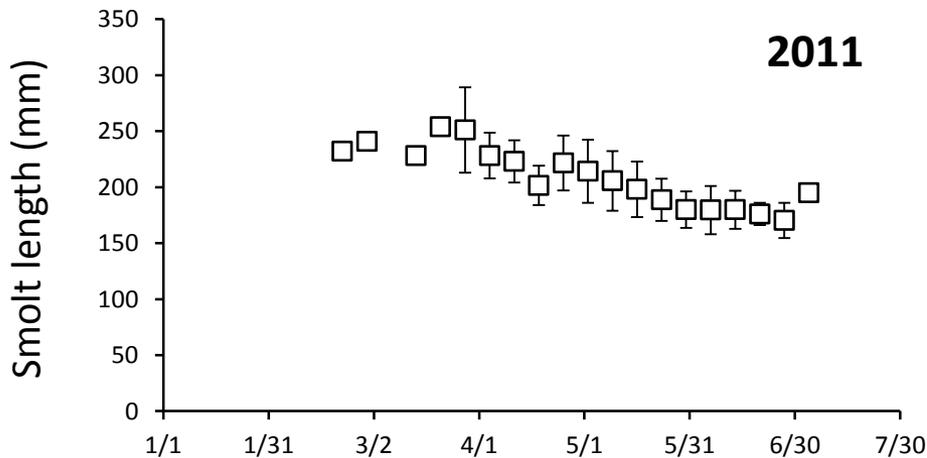
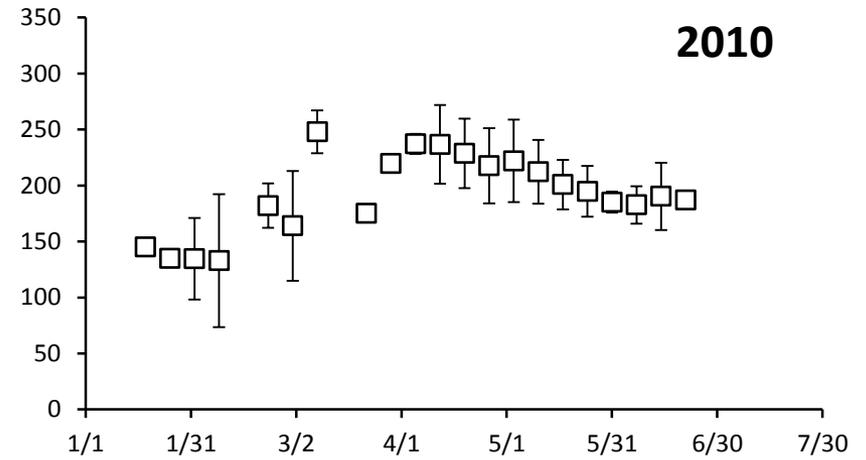
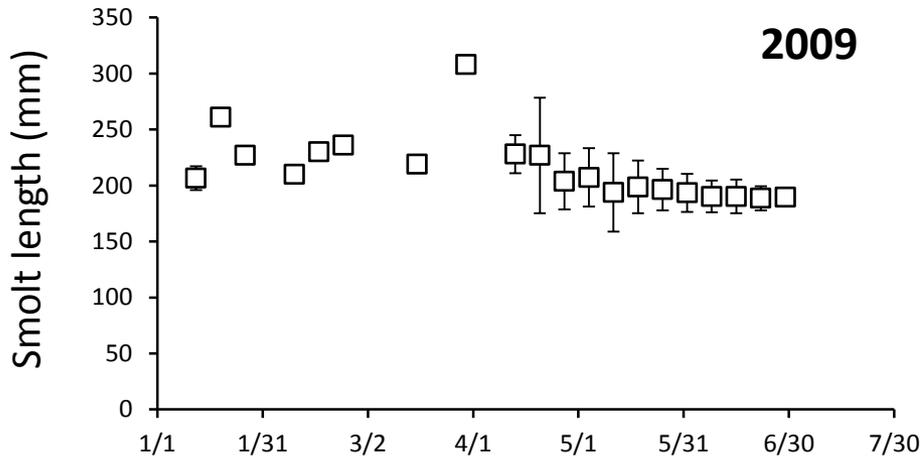
Distance upstream	76 km	115 km	133 km
Basin area	140 km ²	120 km ²	132 km ²
Smolt abundance estimate \pm SE	2,464 \pm 811	2,705 \pm 253	8,253 \pm 6,243
Smolt age structure	N = 27	N = 119	N = 31
age-1	7 %	0 %	0 %
age-2	74 %	4 %	32 %
age-3	19 %	90 %	55 %
age-4	0 %	6 %	13 %

Skagit tributaries

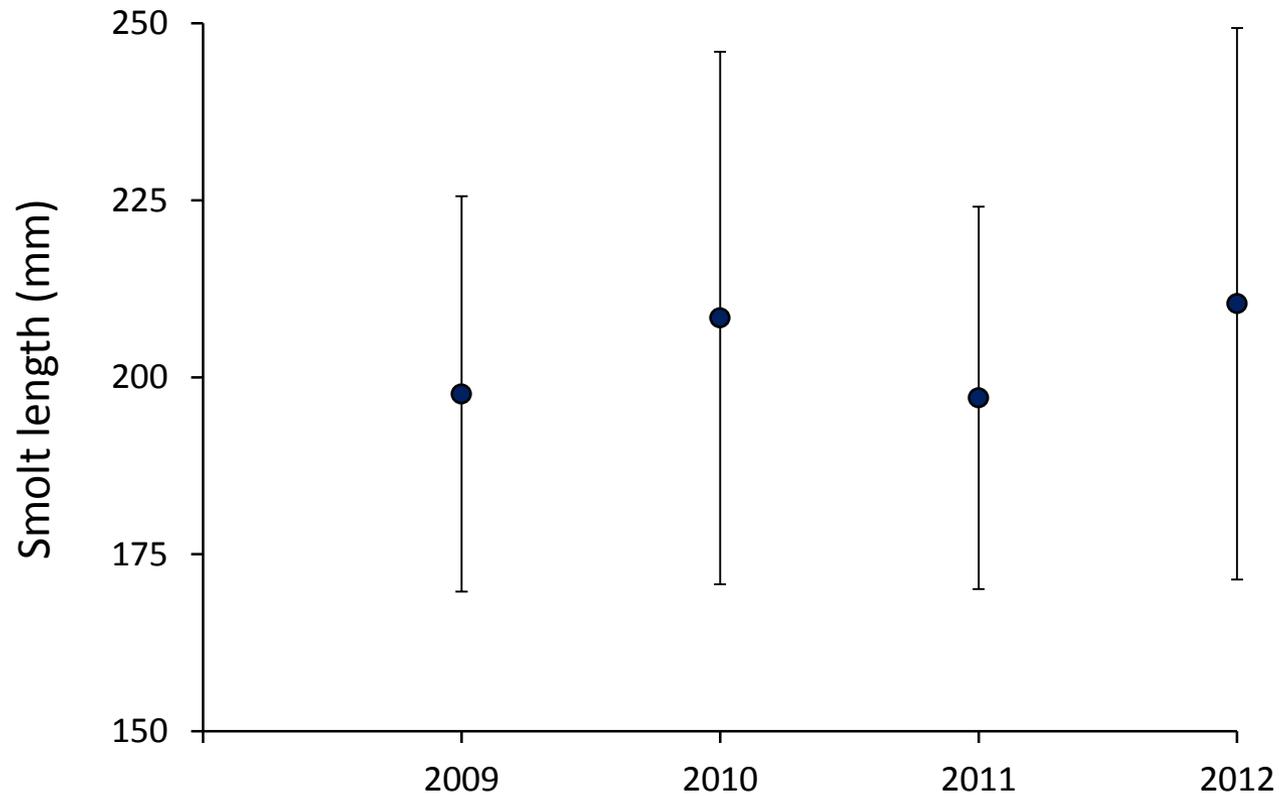


Smaller smolts migrate later

Nisqually River, mean size \pm SD



Nisqually pink salmon effect?



Fish In, Fish Out

Adults



Marine survival

Freshwater productivity

Smolts



A diverse life cycle approach

Adults



Egg to parr survival

Maturation rate

Parr

Mature residents

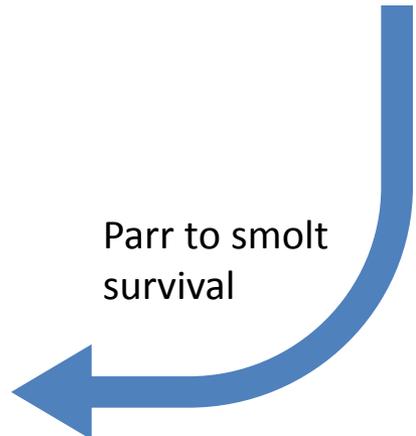
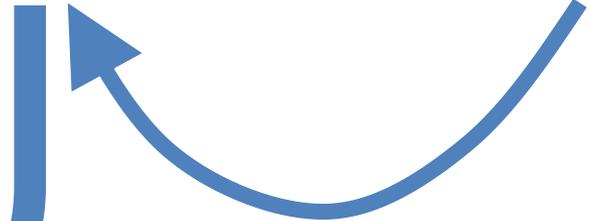
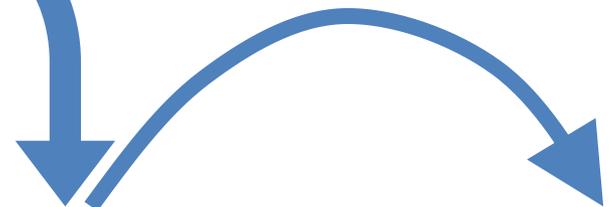
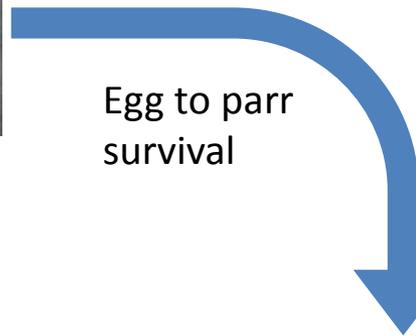
Marine survival

Resident reproductive contribution

Smolts

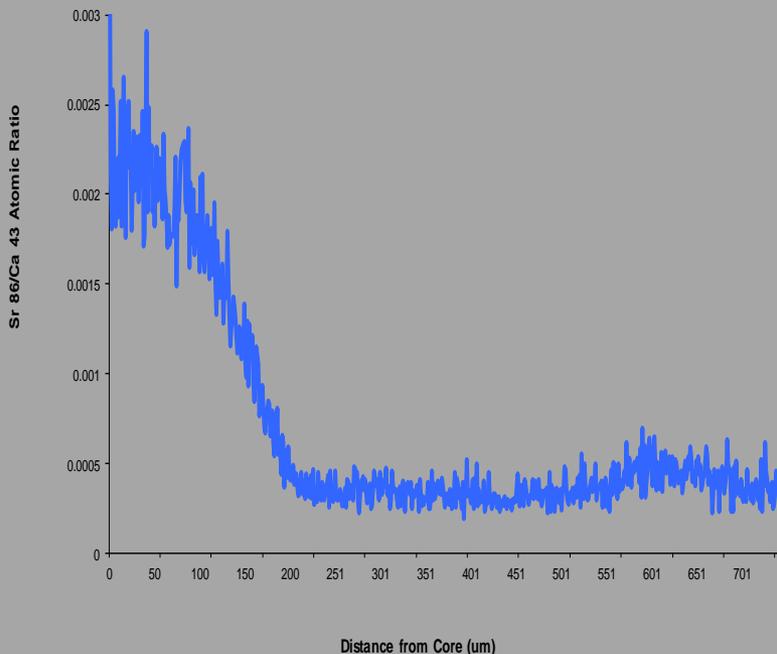
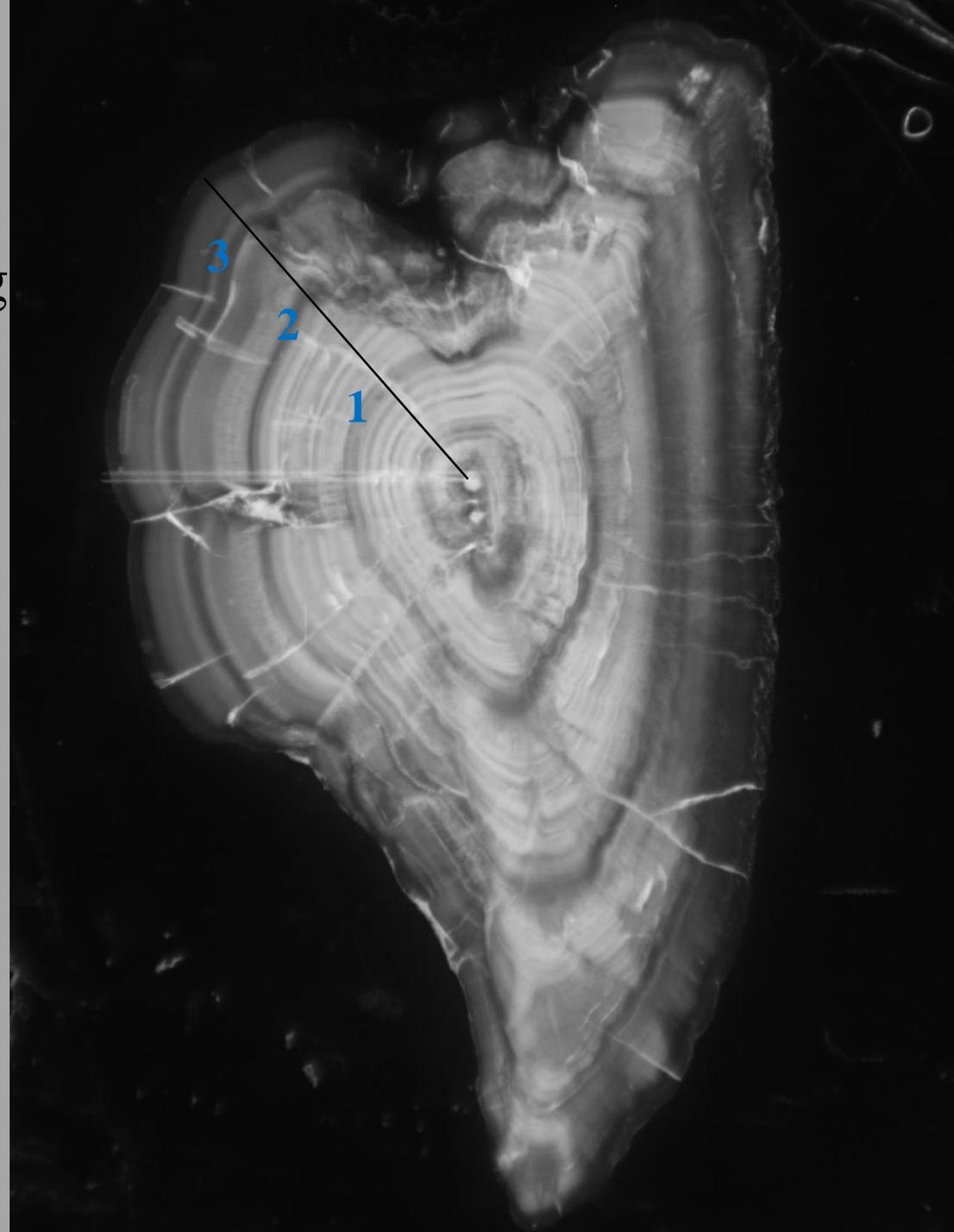


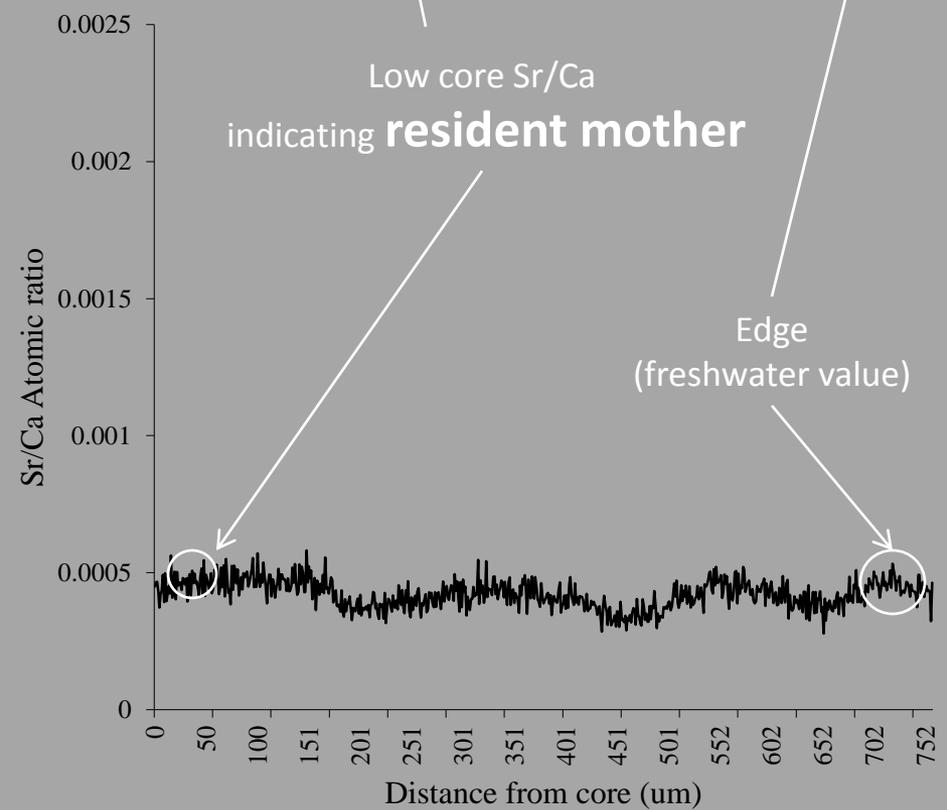
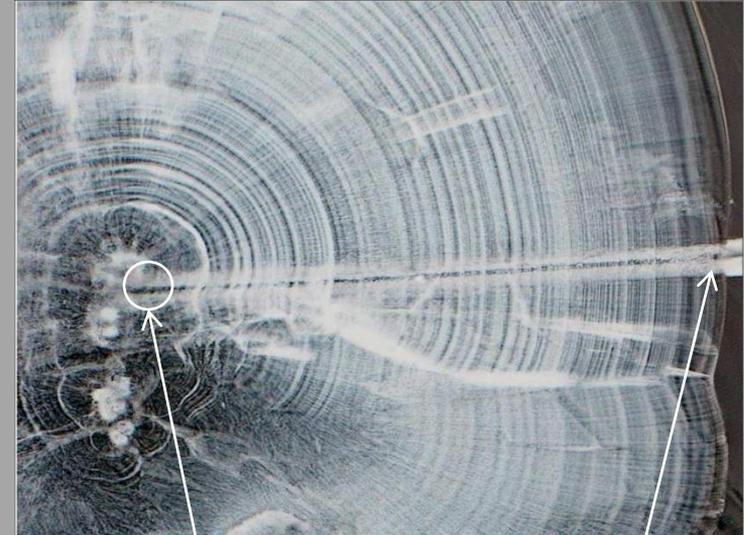
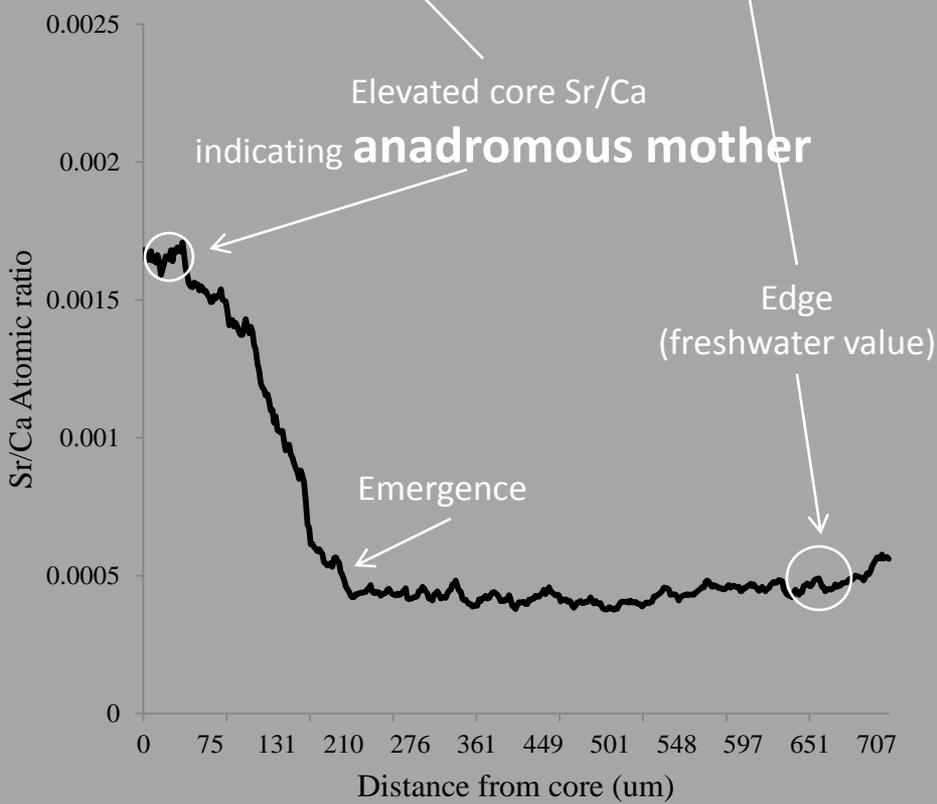
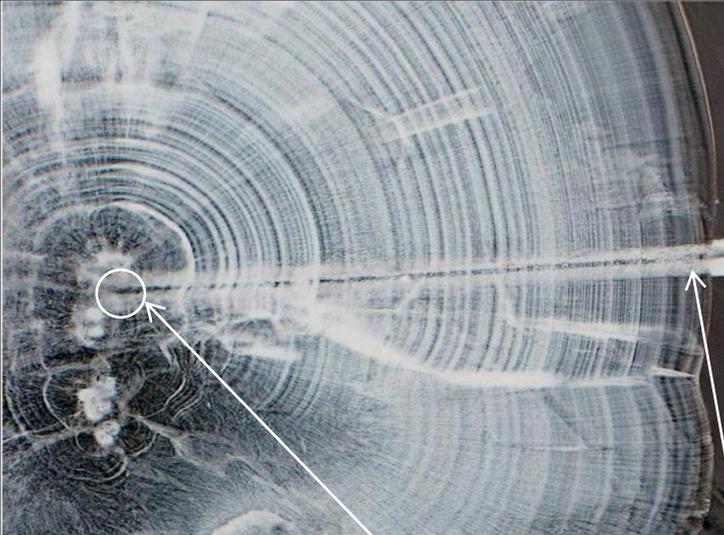
Parr to smolt survival



Otolith microchemistry to determine anadromy through a maternal strontium (Sr) signal using LA-ICPMS

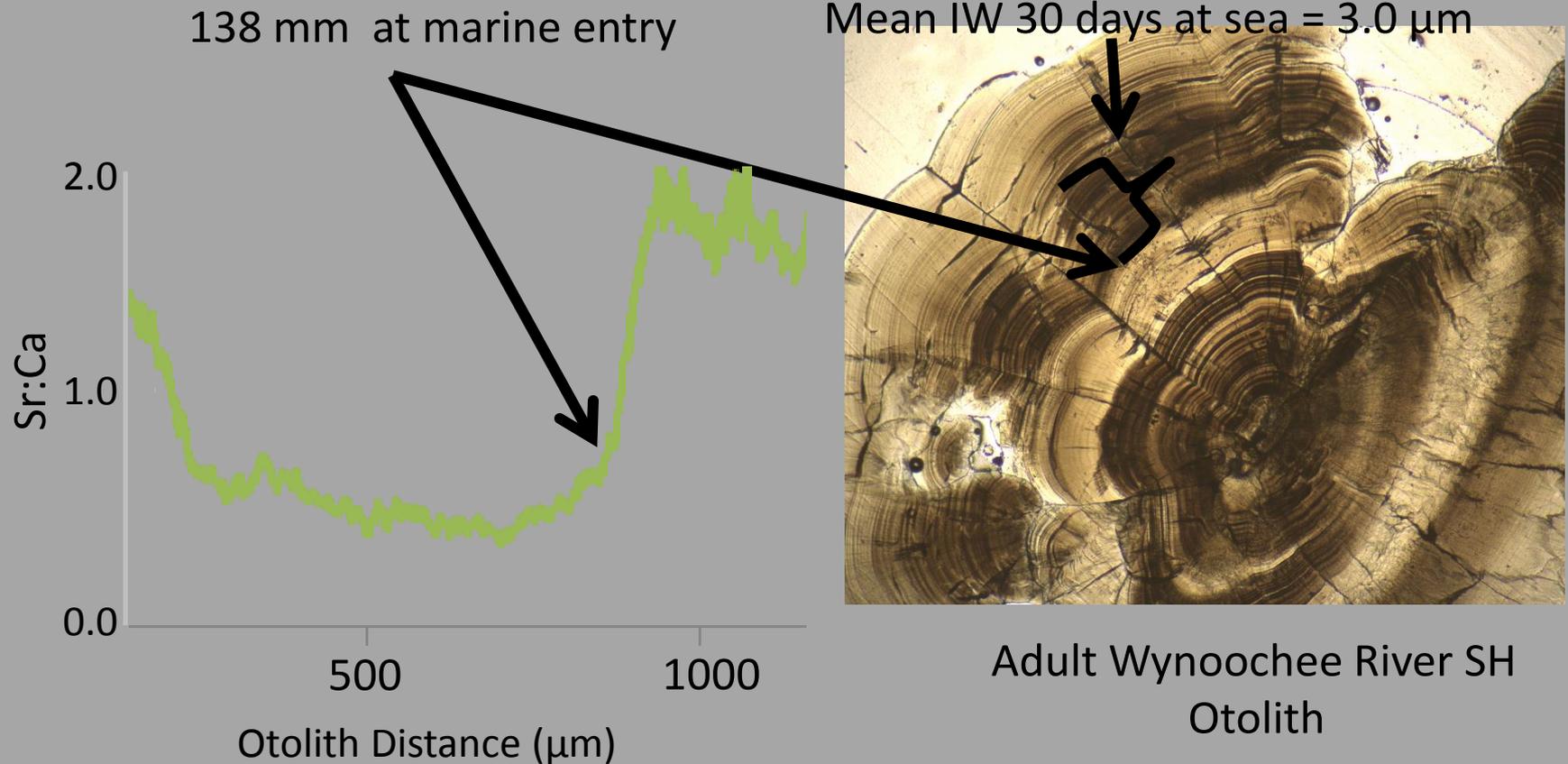
Investigators: Lance Campbell,
Andrew Claiborne





Estimating Growth & Size at Marine Entry

- Otolith Sr:Ca for point of marine entry
- Otolith daily increments (IW) to estimate early marine growth



Puget Sound steelhead genetics

Principal Investigator: Ken Warheit

1. Puget Sound steelhead genetic baseline

- Conversion to more powerful Single Nucleotide Polymorphism (SNP) markers
- Additional sample collection to fill gaps based on TRT populations

2. Hatchery effects

- Next generation sequencing: genomic approach to identify SNP markers associated with hatchery impacts
- Understand domestication process and detect effects on wild populations
- Segregated hatchery programs: extent, magnitude and consequences of introgression in wild populations
- Integrated hatchery programs: single generation genomic effects

Summary

- **Monitoring program positioned to measure population-level responses to recovery actions**
- **Adults: long time series and many populations, but difficulty estimating precision**
- **Smolts: few populations and shorter time series, but methods quantify uncertainty**
- **Addressing diversity with a combination of traditional and new tools**

WDFW monitoring gaps and research needs

1. Lining up adult and smolt abundance estimates

Design smolt trap studies for steelhead

Explore new methods for adult abundance: SONAR, PIT arrays, mark-resight

2. Additional monitoring for summer run life history

3. Design quantitative studies that capture life history diversity

Egg to parr survival

Parr to smolt survival

Reproductive contribution of resident fish

Repeat spawning